1921

Geology and ore deposits of Bedrock Gulch, La Plata county, Colorado

John Tipton Lonsdale
State University of Iowa

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https://doi.org/10.17077/etd.8ffmo41n

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THE GEOLOGY AND ORE DEPOSITS
OF
BEDROCK GULCH, LA PLATA COUNTY, COLORADO

—by—

John T. Lonsdale

A Thesis
submitted to the Faculty of the Graduate College,
University of Iowa, in partial fulfillmant
of the requirements for the degree of
Master of Science

-----------------------------

Iowa City
1921
# THE GEOLOGY AND ORE DEPOSITS

OF

BEDROCK GULCH, LA PLATA COUNTY, COLORADO

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Fig. 1. Index Map of Southwestern Colorado.
THE GEOLOGY AND ORE DEPOSITS
OF
BEDROCK GULCH, LA PLATA COUNTY, COLORADO
CHAPTER I
INTRODUCTION

Bedrock Gulch is a very small part of the La Plata Mountains of southwestern Colorado. These mountains because of the occurrence of gold and silver within their borders have attracted the attention of many geologists and mining activity in the region is the justification of the present report. Some of the geologists who have visited the region like Holmes were concerned with reconnaissance surveys so common in the "seventies" while others like Emmons visited the La Plata mountains to examine mining properties. In 1896 and 1897 the U.S. Geological Survey as a part of its southwestern Colorado program published a folio on the La Plata Mountains with a section on the economic geology by C. W. Purington. Through all the years geologists and other persons have been attracted to this region primarily because of metal mining and today this is still the lure for a number of people. This report originally intended to embrace the entire La Plata region for the purpose of bringing mining and geological data up to date has been restricted to a discussion primarily of Bedrock Gulch and even for this small area the data in some cases is lacking in completeness.

The maps and diagrams shown with this report are as complete as it is possible to make them with the data at hand. Their inadequacy is realized and they are included with the report in the hope that they may aid in an understanding of conditions in
the region under discussion. More field work will lead to more complete results. The conclusions reached in this report are based not only upon field work but also upon a microscopic study of the ores and rocks of the gulch. Somewhat complete collections of the ores and rocks were made; these were supplemented in some cases by assays and smelter returns. From these data an attempt will be made to discuss the geography, history, production, areal geology, structural geology and the ore deposits as completely as possible.

Field Work

During the summer of 1920 five weeks were spent in a field study of this region. The first two weeks were devoted to a general survey of conditions in the territory surrounding Bedrock Gulch while the following three weeks were devoted exclusively to an examination of Bedrock Gulch. This work it is hoped will be but the beginning of the examination of the La Plata Mountains the results of which it is hoped will justify a larger and much more comprehensive report.

Acknowledgments

The writer is greatly indebted to professor G.F. Kay of the State University of Iowa. This report was prepared under his supervision and his helpful criticism has been of great value in its preparation. Professor J.J. Runner, of the same institution has given many valuable suggestions in studying the ores of the gulch. To Messrs. McCausland, Lezie and Beach of La plata the writer is indebted for many suggestions and many personal courtesies. The writer has been free to draw upon published sources
for much of the material under general geology. Certain tables have been copied from publications of the U.S. Geological Survey and to these references has been made in all cases.

Previous Work in the Region

The following list includes all references obtainable upon the geology of the La Plata district. Only a very few bear directly on the ore deposits of Bedrock Gulch but are valuable nevertheless for an understanding of the geology of the district. Probably the most complete account is folio No. 60 of the U.S. Geol. Surv.

Atwood, Wallace W. and Mather, Kirtly F.
The evidence of three distinct glacial epochs in the pleistocene history of the San Juan Mountains.

Austin, W.L.
Telluride veins in the La Plata Mountains.

Clarke, F.W.
Analyses of rocks and minerals from the laboratory of the United States Geological Survey, 1880 to 1903.

Comstock, Theodore B.
The geology and vein structure of southwestern Colorado.

Cross, Whitman.

Cross, Whitman, Spencer, Arthur Coe, and Purington, Chester Wells.


Endlich, F. M.

Freeman, Henry C.

Hartman, Frank.
Hillebrand, W.F.
Distribution and quantitative occurrence of vanadium and molybdenum in rocks of the United States.

On an interesting variety of lollingite and other minerals.

Hill, J.M. and Lindgren, W.
The mining districts of the western United States with a geological introduction by W. Lindgren.

Hills, R.C.
Types of past eruptions in Rocky Mountains.

Holmes, W.H.
Report as geologist of the San Juan division.

Ihleseng, M.C.
Review of the mining interests of the San Juan Region.

Lakes, Arthur.
The Needles, La Plata Mountains.
The La Plata Mountains of Colorado, a description of the telluride veins and the Mancos contact.
The contact deposits of the La Plata Mountains.
The La Plata Mountains. Observations on their formation and
the influence of the different igneous rocks upon mineralization.
Mines and Minerals, vol. 23, pp. 222-223, Illust., 1903,
Lee, Harry A.
Uranium in Colorado.
Report of the State Bureau of Mines, Denver, for the years 1901-2
Lindgren, Waldemar.
The geological features of the gold production of North America.
Peale, A.C.
On a peculiar type of eruptive mountains in Colorado.
Petre, R.W.
Mines of La Plata Mountains.
and occurrence of precious minerals.
Rickard, T.A.
The development of Colorado's mining industry.
Mining in Colorado, 1895.
Min. Ind., Vol. 4, pp. 315-318; 1896; Description of gold deposits of La Plata county.

Geological distribution of the precious metals in Colorado.

Spurr, Josiah E., Garrey, G.H., and Ball, Sydney H.

Sweetser, A.L.
The La Plata Mountains.
Mg. Sci., vol. 64, pp. 229, 1911.

Toll, R.H.
La Plata Mountains.

Triangulation and Spirit leveling, 1898.

Woolsey, L.H.
Volcanic ash near Duraugo.
Fig. 2. Topographic map of the La Plata Mountains.
CHAPTER II
GEOGRAPHY

Bedrock Gulch lies in the southwestern part of the La Plata Mountains in southwestern Colorado in longitude 108 degrees 5 minutes west and latitude 37 degrees 24 minutes north. This gulch is a part of the La Plata Mining District, once known as the California Mining District, 24 miles northwest of Durango. A spur of the Rio Grande Southern Railroad runs to Mayday, a small mining town three and one-half miles south of the mouth of Bedrock Gulch. The small inland town of La Plata is situated at the mouth of the gulch and has access to the railroad at Mayday by a good automobile road. There is a good wagon road in the south part of Bedrock Gulch and a trail in the north part serving the Allard Mining Company and the Copper Hill Company respectively.

The La Plata Mountains are one of those isolated groups of peaks which rise above the plateau level in certain parts of Colorado, Utah, Arizona, and New Mexico. The La Plata Mountains have been compared as to situation and origin with El Lote, Carriso, Abajo, La Sal and Henry Mountains. The La Platas lie about twenty miles southwest from the front of the San Juans. Their general shape is circular, the diameter of the circular area being about ten miles. The greater portion of the area covered by these mountains is in La Plata County, Colorado, but their western edge extends a short distance into
Montezuma County. Bedrock Gulch is in the southwestern part of the La Platas and lies in both La Plata and Montezuma Counties.

The most prominent slopes in the region rise from elevations of about 9,000 feet to elevations, on the higher peaks, of over 12,000 feet and in a few cases, such as Hesperus Peak, Mount Moss and Banded Mountain, to elevations of over 13,000 feet. These main slopes in general rise, from the valley bottoms, very rapidly for about 1,300 feet, on an average, but from this elevation their ascents are gentler almost to the divide. The divide in many cases is sharp with numerous precipitous cliffs several hundred feet high. It will be seen consequently that there is an interruption in the profile of the slope. This interruption is taken account of in trails, which are curved and tortuous near the valleys but which are often fairly straight and easy of passage farther up the slopes. The interruption in profile, mentioned above, where developed along the divides of adjacent gulches results in ridges which are conspicuously similar. The divides between Bedrock, Madden and Boren Gulches are of this nature.

The La Plata River and Mancos River are the main drainage channels of the region, the former draining the central portion of the mountains the later serving in a similar capacity for the western part. Both of these streams are permanent streams.
and in the spring and early summer carry noticeably larger volumes of water than in the autumn and winter. Both are fed from tributaries depending largely upon snow for their source of supply in most cases these tributary streams are permanent also. Bedrock Creek is tributary to the La Plata River and is a permanent stream. It carries enough water for mining purposes in the Gulch. The La Plata River is sufficiently large to afford abundant water power for most mining projects.

In summer time rain is abundant in the La Plata Mountains. In an average summer there is usually a time, approximately a month in length, during which rains are a daily occurrence. The remainder of the summer is free from rain. Snow falls usually about the last of October though violent snow storms have occurred much earlier but during the exceptional winter no snow fell until January. In the spring the roads become passable during the month of May. The winters are cold but not extremely so. Mining operations are entirely possible during winter though it is usually necessary to have provisions stored up to cover a period of three months while the roads are not passable for freighting.

Vegetation, except upon the highest slopes, is abundant. Above an elevation of 11,500 feet this is limited to grasses and scrub trees but below this elevation there are thick growths of pine, spruce, poplar and smaller types of vegetation. This timber supply is always sufficient for mine purposes and Bedrock Gulch is no different in this respect from the other
gulches of the region since in Bedrock Gulch the timber supply is abundant.
Fig 3  The La Plata Mining District
CHAPTER III
HISTORY AND PRODUCTION

The history of mining in the La Plata Mountains cannot be given accurately for every year since mining was started in the region. Records in the various mining publications are no means complete and residents of the district differ widely in regard to various details of the history of the camp. Toll (1) writing in the Mining and Scientific Press in 1908 characterized the district as follows "The La Plata Mountain district is one of the Rip Van Winkle mining districts of Colorado that have been asleep for many years and are just attracting the attention of capital. It has been roused a number of times before, but on commencing to stir it has been hit in the eye by some marauding speculator." Unfortunately this statement represents only too faithfully conditions which have existed in the district. Too often properties were acquired for other purposes than mining.

An examination of the best sources obtainable shows that the attention of the mining world was directed to the La Plata Mountains sometime between 1873 and 1878 by discovery of rich ore on the Comstock claims on La Plata River. The rush to the district which followed resulted in the making of many locations and considerable development work. Parrott City the first county seat of La Plata County was built at the mouth of La Plata canyon on nearly the same location as the present
settlement of Mayday. Properties which were prominent during this early period were the following: Comstock, Cumberland, Century, Tippecanoe, Belle Hamilton and Ashland. During this time the district was sometimes called the California District. The pioneers all sought high grade ore. Several prospects were able to ship from the very grass roots ores high enough in value for large profits. Some of these ores were sufficiently rich to be hauled, by oxen to, Pueblo a distance of about 300 miles.

After about 1883 this pioneer activity in the region became much less. Adequate records for this time are not available; in fact little can be told of the district until 1896 when Purinton (2) reports the following properties actively engaged in mining, Duraugo Girl, Jenny Lind, Small Hopes, Little Kate, Shoofly and Mountain Lily. About 1904 the Mayday mine was discovered near the mouth of La Plata canyon. This has been the, without question, the richest property in the district since it alone has produced over $1,000,000 in gold and silver. In 1908 (3) the following properties were reported to be operating, Old Kentucky, Gold Dollar, May Day, Valley View, Movoaaratz, Little La Plata, Lucky Four, Bonnie Girl, Tomahawk, Small Hopes, White Diamond, Portland, Fassbinder, Gold Kind and Swamp Angel. Starting with the discovery of the Mayday mine the district experienced its greatest activity. The Idaho mine near the Mayday was developed and though eventually
it ceased to operate because of litigation produced nearly $500,000. Development work over the entire district was considerable and several mines were shipping ore. The little mining town of La Plata in the heart of the mountains boasted a hotel, two stores, two saloons and about a dozen dwellings. During this period also the copper deposits of Bedrock Gulch were prospected and developed to a considerable extent. About three-thousand tons of copper ore were shipped to the Durango smelter. Activity but not production reached its highest point in the district in 1916 when the U.S. Geological Survey reported 36 active mines though these produced far less than 8 mines in 1910. The character of the activity of many of the mines listed for this period may safely be questioned.

The world war almost completely paralyzed mining activity in the La Plata Mountains. In 1920 nearly two years after the armistice not a single property in the entire district was shipping ore. The Lewis Mountain Mining Company and the Boren Gulch Company were doing development work and assessment work on most of the claims in the region was also being done by evidences of profitable mining were absent. High treatment prices combined with high production costs have prohibited the operation of nearly every property in the district. It is believed however that conditions are improving. With mining costs nearer normalcy it is confidently
expected that mining activity in the La Plata Mountains will revive and that there will be a future for the district.

Bedrock Gulch has played a small part in the history of the district. High grade ores have never been found there and happily no "marauding speculator" has selected this place for his operations. The Copper Hill property has developed a considerable body of copper ore and has shipped considerable amounts of it. The war forced this property to become idle. The Allard Company whose holdings are situated across the gulch from Copper Hill has never developed any bodies of copper ore and has shipped insignificant amounts of gold and silver ores.

Purington (4) estimates the production of the district previous to 1896 as $300,000 equally divided between gold and silver. There are no figures available from 1896 to 1904. Below is a production table covering the years from 1904 to 1906 (5). The copper output shown on this table came almost entirely from Bedrock Gulch. The location of some of the more prominent properties is shown on the accompanying sketch map.
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Previous to 1896: 300,000

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(3) Ibid
(4) Ibid
Figure 4: Areal Geology Sheet

Legend:
- Lead Silver Veins
- Diorite
- Syenite
- Dmp
- Diorite Monzonite - Porphyry
- Jip
- La Plata Sandstone
- Jd
- Dolores Formation

Burwell Peak
Gibbs Peak
Bedrock Creek
La Plata
Madden Creek
Neptune Creek

1:5000 scale
54" x 81"
Stratigraphy

The sediments of the La Plata Mountains are generally speaking siliceous in character. Those of Bedrock Gulch are entirely so. In the entire district only a few thin beds of limestone are known and a few shale partings. Outside of the mountains this siliceous character is not so prominent. The few limestone beds known are of importance in the history of certain gold and silver deposits of the region but have not influenced in any way the ore deposits of Bedrock Gulch. In the district there are several distinct sedimentary formations but in Bedrock Gulch only two of these are present, the Dolores formation and the La Plata formation. Only these will be described.

Dolores Formation

The Dolores formation best known as "Red Beds" attains a maximum thickness of 1700 feet in the La Plata Mountains and a thickness of 2000 feet in the region to the north. In Bedrock Gulch about 800 feet are believed to be present. Because of the numerous intrusive igneous bodies the extent of the Dolores formation cannot be determined accurately. Single beds while traceable for considerable distances are invariably cut off by bodies of igneous rock. In the Bedrock Gulch there is nowhere to be found more than 600 feet of
continuous rock belonging to this formation and the majority of occurrences are much smaller in extent. Much of the true character of outcrop is of course hidden by vegetation but the patchwork arrangement of outcrop is believed to be most characteristic. Definite boundaries cannot be assigned to the formation and its actual extent is not known but it certainly is smallest in extent of the rocks of Bedrock Gulch.

In lithologic character the portions of the Dolores formation found in Bedrock Gulch vary from coarse hard sandstone to dense fine quartzite. The color varies from dull red to greenish gray. In Bedrock Gulch the greater part of the formation does not exhibit the red color which has given the formation its popular name "Red Beds." This is believed to be due in part at least to the baking and metamorphic effects of the intruding igneous rock masses. New minerals, especially epidote have been developed and the whole rock rendered extremely dense and compact. The greater part of the formation as developed in Bedrock Gulch is quartzitic in character and is not typical of the formation as described from other regions. In the neighboring gulch, Boren Gulch, the Dolores formation is developed in long exposures of brilliant red sandstones and grits. The variation, from this and other exposures, found in Bedrock Gulch is believed to be due to the action of the igneous rocks. No fossils have been found in this formation in the La Plata district.
though some Saurian and a few invertebrate remains have been described from the Telluride and Rico districts. (1)

The United States Geological Survey (1) assigns this formation to the Triassic period, basing the correlation partly upon fossils and partly upon lithologic character. This correlation will be adopted by this report.

La Plata Formation

The La Plata formation or as it is commonly called the La Plata sandstone attains a maximum thickness of 500 feet in the La Plata Mountains and is best known in this district. It like the Dolores is also known in the region to the north but unlike the Dolores is thinner in those regions than in the La Plata Mountains. In Bedrock Gulch the La Plata formation attains a thickness of 200 feet. In Bedrock Gulch the formation is found on the divide between East Mancos river and Bedrock Gulch forming the crest of Gibbs Peak and some of the sheer cliffs to the north of Gibbs Peak. This formation can truly be said to be a "cliff maker" since its weathering produces vertical or nearly vertical faces which are present everywhere the formation is exposed. Since the color of the rock is nearly white these cliffs form a very conspicuous feature of the topography. This fact has been noted by Cross (1) in his report on the region.
In Bedrock Gulch the La Plata formation is composed of dense white quartzite, very fine grained and very constant in character. Described from other portions of the district as a friable sandstone it here has none of this character and is exceedingly tough quartzite. This variation from typical exposures as in the case of the Dolores formation described above is believed to be due to the influence of igneous rocks. Elsewhere the formation is divided into a lower and upper member by a bed of black limestone 20 feet in thickness. Since this is not present in Bedrock Gulch only the lower portion of the formation is believed to be present. The boundary between the La Plata formation and the igneous formations is sharp and because the La Plata formation outcrops in peaks and cliffs as observed above, this boundary is well shown. In Gibbs Peak the contact between the La plata formation and the adjacent igneous rocks is a matter of less than two feet and stands out as a sharp line since the two formations differ in color. Chilling effects were observed in the igneous rocks but no boundary phenomena could be seen in the quartzite. The La Plata formation is not fossiliferous.

Igneous Rocks

All of the igneous rocks of Bedrock Gulch and also
of the entire La Plata Mountains are of the intrusive type. Commonly they occur in large bodies of the stock type but the diorite-monzonite-porphyry to be described later occurs commonly also in smaller bodies. It is believed that the entire series of igneous rocks in the region are closely related in origin and perhaps may be but differentiation products of the same parent magma. In Bedrock Gulch there are three distinct igneous rock types and these will be described.

Diorite-Monzonite-Porphyry.

The term diorite-monzonite-porphyry is given by Cross (2) to a whole series of porphyritic igneous rocks whose characters range between the extremes of diorite and monzonite. In Bedrock Gulch the occurrences of this series are probably nearer the diorite extreme of the series than the monzonite extreme. In Bedrock Gulch this igneous rock occurs in a body which has more the character of a sheet or several sheets than the character of a stock. It is not found in any great continuity and in many cases is distinctly sheet like in character. It is considered since the exact character of occurrence has not been determined that a series of sheets best explains the formation as observed in Bedrock Gulch. Its boundaries are not entirely known as indicated on the areal geology map by dotted lines.

The rock is distinctly porphyritic in texture.
Phenocrysts of white and gray feldspar are found imbedded in a dense dark gray ground mass with an occasional phenocryst of hornblende. Very rarely biotite and quartz crystals are observed. This rock has been subjected to the greatest weathering of any of the igneous rocks of the gulch. It is older and has been exposed for a longer period of time which may account for the greater amount of weathering. It is not uncommon to find masses of the rock altered almost entirely to kaolinite but retaining the original texture of the feldspar and associated minerals and in such a fragile condition that they can be readily crushed and crumpled in the hand. In such cases the feldspar phenocrysts are shown as white specks of kaolinite in a brown earthy mass.

Microscopical examination of the diorite-monzonite-porphyry reveals lime-soda felspar, potassium feldspar, hornblende, biotite and quartz with titanite, magnetite and apatite, magnetite and apatite as accessory minerals. Plagioclase feldspar is the most common feldspar and the ground mass is decidedly feldspathic. The feldspathic constituents are far in advance of the ferro-magnesian though the hornblende when present is so in larger crystals than the feldspar.

W.F. Hillebrand (3) of the United States Geological
Survey has analyzed the rock with the following results:

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<tr>
<th>Chemical</th>
<th>Mass %</th>
</tr>
</thead>
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<td>16.67</td>
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</tr>
<tr>
<td>MgO</td>
<td>2.18</td>
</tr>
<tr>
<td>CaO</td>
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<tr>
<td>BaO</td>
<td>.12</td>
</tr>
<tr>
<td>SrO</td>
<td>.11</td>
</tr>
<tr>
<td>Li₂O</td>
<td>Trace</td>
</tr>
</tbody>
</table>

Augite-Syenite

The augite-syenite occurs over a considerable area of Bedrock Gulch, as shown on the areal geology map, occupying the central part of the gulch and extending from a point near Gibbs Peak southeastward across La Plata river. The shape and extent of its outcrop indicates that this rock body is a stock. Its eastern extent is considerable and while not shown on the map is known to extend more than a mile east of La Plata river.

This augite-syenite is fairly coarsely crystalline and is gray to pinkish gray in color. On fresh surfaces green augite may be observed occurring in distinct prismatic crystals. The feldspars constitute by far the largest part of the rock and the ease with which they are weathered has
determined that the entire body of augite-syenite weathers rather easily. In degree of weathering the augite-syenite is exceeded only by the diorite-monzonite-porphyry described above. The weathering effects are similar, the feldspars and augite remaining as kaolinite and limonite respectively. Very infrequently biotite is observed in the syenite. It is of interest to note that pure specimens of the augite-syenite are difficult to obtain from Bedrock Gulch since nearly everywhere chalcopyrite and pyrite are present in specimens. To a lesser extent this is true of the diorite-monzonite-porphyry described above. These two igneous rock formations are both well weathered and it seems reasonable to assume that the degree of weathering has been influenced directly by the amounts of pyrite and chalcopyrite present in the rock. Upon leaching these minerals especially the pyrite produce sulphuric acid and the presence of sulphuric acid in solutions having access to the rock bodies would tend to weather them much more rapidly than if this were not present.

Under the microscope the feldspars are seen to be mainly orthoclase though anorthoclase and microperthite were identified by Cross. (4) The augite which has given the rock its name is pale green the biotite light brown. Titanite, magnetite and apatite the common accessory minerals of igneous rocks are developed to a slight extent.

H. N. Stokes (4) of the United States Geological
Survey has analyzed the rock with the following result:

\[
\begin{align*}
\text{SiO}_2 & \quad 59.79 \\
\text{Al}_2\text{O}_3 & \quad 17.25 \\
\text{Fe}_2\text{O}_3 & \quad 3.60 \\
\text{FeO} & \quad 1.59 \\
\text{MgO} & \quad 1.24 \\
\text{CaO} & \quad 3.77 \\
\text{Na}_2\text{O} & \quad 5.04 \\
\text{K}_2\text{O} & \quad 5.05 \\
\text{H}_2\text{O} & \quad .58 \\
\text{TiO}_2 & \quad .67 \\
\text{CO}_2 & \quad .72 \\
\text{P}_2\text{O}_5 & \quad .35 \\
\text{SO}_3 & \quad .04 \\
\text{Cl} & \quad \text{Trace} \\
\text{MnO} & \quad .20 \\
\text{BaO} & \quad .14 \\
\text{SrO} & \quad .11 \\
\text{Li}_2\text{O} & \quad \text{Trace}
\end{align*}
\]

Specific gravity 2.704 at 25 degrees Centigrade

Diorite

A small stock of diorite occurs near the end of the ridge between Madden Gulch and Bedrock Gulch. No other occurrence is known in Bedrock Gulch and the extent of this
occurrence to the north is not known. The diorite occurs in the bed of Bedrock Creek but to the north of Bedrock Creek the outcrop is lost because of vegetation. It cannot extend very far in this direction for but a few hundred feet north of Bedrock Creek at this point the diorite-monzonite-porphyry and augite-syenite are known to outcrop. The importance of this rock in discussing the ore deposits of Bedrock Gulch is problematic though the diorite apparently furnishes the most likely source for the ore bearing solutions. It is the only igneous rock of Bedrock Gulch not containing chalcopyrite and pyrite in noticeable amounts and since it is of the type known in other places as ore makers is considered tentatively at least as the source of the ore bearing solutions since their actual source cannot be proved.

The diorite is a grayish rock with no hint of pink color so common in the igneous rocks of Bedrock Gulch. The predominant colors are white and black, the white being derived from feldspars the black from biotite, augite and hornblends. The mass of the rock is distinctly crystalline though rather finely so. This rock is almost totally lacking in the weathering phenomena seen in the other igneous rocks of the gulch. Where found even in broken blocks and detached pieces there is no evidence of weathering and the surfaces are fresh and bright. This is a great contrast to the other igneous rocks above and is believed to be due to
the absence of metallic sulphides in the diorite.

Under the microscope alkali and soda-lime feldspars are seen to be present in nearly equal amounts. The one is orthoclase and the other mainly labradorite. The augite is the same as in the syenite as are also the hornblends and biotite though these last three are present in larger amounts as would be expected.

W. F. Hillebrand (5) of the United States Geological Survey has analyzed the rock with the results given below. Rough calculations show that the feldspars constitute two-thirds of the rock with labradorite more abundant than orthoclase.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>SiO$_2$</td>
<td>55.53</td>
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<tr>
<td>Al$_2$O$_3$</td>
<td>16.39</td>
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<tr>
<td>Fe$_2$O$_3$</td>
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<td>NiO</td>
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Specific gravity 2.79 at 21 degrees Centigrade
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<th>Compound</th>
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<tr>
<td>FeS₂</td>
<td>.04</td>
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</table>

(2) Ibid. p. 6
(3) Ibid. p. 7
(4) Ibid. p. 6
(5) Ibid. p. 6
The red is Lead-Silver veins faulted by NW-SE fault system.
The few earlier EW fissures occupied also by Lead-Silver veins were faulted by N.E.-S.W. fissures with slight displacement.
Bedrock Gulch shares in the general structure of the La Plata Mountains and in addition has its local structural features. The La Plata Mountains are a group which has often been referred to as one of the typical laccolitic mountains. Cross (1), Endlich (2) Holmes (3) and others have repeatedly mentioned this group of mountains along with Rico, El Late, Carriso, Abajo, La Sal and Henry Mountains. These all lie in the same general region; that is, southwestern Colorado, New Mexico and Utah. All are believed to have resulted from extensive igneous activity about Eocene time. The horizontal strata of the region were uplifted into domes which subsequently have been eroded into the present topographic forms.

The La Plata Mountains are surrounded on all sides by regions in which the strata are nearly horizontal. Situated as they are at fairly great distances from other mountain groups the effects of diastrophic movements in other regions were felt only slightly, if at all, in the La Platas. These mountains afford then through their rather complete isolation an excellent opportunity for a study of the laccolitic type of mountain. A survey of the La Plata Mountains shows that they truly form a dome. On all sides
the sedimentary rocks dip sharply away from the flanks of the mountains with gradually diminishing dips as the mountains are left behind. In the center of the group the portions of sedimentary rocks left have no regular arrangement and may exhibit all manner of irregularities but around the flanks the dome character is pronounced. The igneous rocks are seen to form the great core of the mountains including the greater portion of the sediments left within the dome.

Bedrock Gulch lies in the southwestern part of this dome but is too far inside to exhibit any of the regular phenomena common to the margin of the mountain group. The sedimentary rocks present there can not be said to possess any constant dip or other arrangement. All except the Dolores and La Plata formations have been eroded away and only a fraction of the last is left occupying the tops of a few peaks and divides.

In Bedrock Gulch and also in the remainder of the district certain fissuring is believed to have accompanied the igneous activity and the formation of the mountains. In some cases the fissuring was effected with little or no displacement while in others there was considerable displacement. The fissuring had a very important part in the development of the ore deposits of the region. There are three distinct systems of major fissuring to be found in the area under consideration. In addition to these major
fissures numerous smaller sets of fissures exist but these cannot be referred to any major system. These major systems of fissuring in certain places are more pronounced than in others and have resulted in distinct zones in which the intensity of fracturing has been so great as to produce brecciation. In other places the fissuring is not so pronounced and the results not so noticeable. The first system of fissures in the gulch is an east-west one whose openings are filled in many cases by lead-silver veins to be described later. Where this system has formed broad zones the fissures are traceable for several hundred feet. These east-west fissures were followed by northeast-southwest fissures which faulted and displaced the east-west system to the extent of a few feet. In this set of fissures most of the major mineralization of the region has been formed. These too in places resulted in broad zones in which the fissuring amounted to brecciation. Veins of the lead-silver type are found in this system of fissures and also copper minerals which are disseminated in the brecciated blocks mentioned above. The brecciated zones produced by this system of fissures are traceable for three hundred yards in some cases and are several hundred feet wide. Finally came a series of northwest-southeast fissures cutting the others and displacing them greatly. These are traceable in some cases for nearly a mile and are believed to have materially
controlled the present outcrop of the ore bodies. An area in which there are many veins of the two earlier systems is commonly blocked off by bounding fissures of this system and most of the ore occurrences seem to be fault blocks explained by this condition.

Two especially pronounced northwest-southeast zones run for a considerable distance over bare rock surfaces and are best observed in the gap north of Gibbs Peak and in the gap north of the first unnamed peak north of Gibbs Peak. These gaps or low places in the divide at the head of Bedrock Gulch could be called passes and are believed to be due to the ease of erosion afforded by the brecciated zones mentioned above. This last set of fissures also results in wide zones and traceable over great distances. The map accompanying shows the two northwest-southeast zones mentioned above with blocks of the other systems displaced. This map shows only the most pronounced examples of fissuring. Others not so easily traced and less intense in results are known to exist. There is a possibility that the present drainage of the gulch and the main topographic features are a direct result of the fissuring systems mentioned above.

The minor fissuring of the gulch is believed to have resulted from the same causes that produced the major ones. It manifests itself in reticulated areas between the major systems. These minor fissures consist of cracks
from the size of a hair to a goodly fraction of an inch in width running in all directions and showing no apparent relation to the larger fissures except that the force which produced long continuous fissure systems also shattered the blocks of rock in between. These minute cracks have afforded channels for ore bearing solutions and have been the cites of most of the copper deposition in Bedrock Gulch.

CHAPTER VI
ORE DEPOSITS

The ore deposits of Bedrock Gulch are of two distinct types. One type is a disseminated low grade copper ore while the other consists of veins containing lead, silver and bismuth. These are the only occurrences of these types known in the entire La Plata region and hence are of especial interest. Earlier investigators were unaware of their existence and indeed both were discovered only by accident.

Copper Ores

The copper ores were first brought to the attention of mining men by their accidental discovery during some assessment work on a group of claims just west of La Plata. Development at this place resulted in what is known today as Copper Hill. At this place Mr. E. N. Beach and associates opened up a considerable body of ore from which shipments were made for several years. A "glory hole" development was attempted and work actively carried on until the world war brought about conditions which prohibited further profitable operation. Smelter returns from all the shipments which were made to the A. S. & R. smelter at Durango are given below:

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<th>Lot No.</th>
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The foregoing list was compiled from the settlement sheets of the A.S. & R. smelter at Durango covering shipments made between May 17, 1911 and November 25, 1915. It can be stated at this time that the chemist of the above smelter in testing the Copper Hill ore determined a small amount of palladium in the ore. He obtained this by combining several pulps so that the amount of palladium present was very small.

McCarthy in his report to the Copper Hill Company estimated the ore reserves of the property as follows:
Positive ore

6,247 tons on dump carrying 2.5% copper

38,350 tons blocked out carrying 3.4% copper

Making a total of 44,490 tons containing 2,912,194 pounds of copper.

Probable ore

140,752 tons of same average copper content.

During the last two years it has been found that noticeable amounts of ore similar to the Copper Hill ore occur over the greater part of Bedrock Gulch, confined however as far as is known to igneous rocks. This has led to a consideration of the copper ores from a more general viewpoint than a mere consideration of the occurrence at Copper Hill and has resulted it is believed in a greater knowledge of their character than has heretofore been known. Mr. E.N. Beach has never ceased his active interest in the copper deposits and others have become interested through him. Mr. Phillip Lezie lesee of the Allard Mining Company has believed the copper deposits to have great possibilities and he was largely instrumental in inaugurating the present investigation. Mr. Ross D. McCausland the manager of the Lewis Mountain Mining and Milling Company properties in the La Plata Mountains became interested and spent considerable time in a study of the ores. The combined ideas of all of these men and the further investigation have established several facts not previously recognized and have
advanced the state of knowledge concerning the ores considerably. Copper bearing ores quite similar to those at Copper Hill are now known to exist over nearly the entire gulch and are found to occur under conditions which indicate that they are parts of the same deposit. It is now believed that any hypothesis or theory which will explain any part of the copper deposits of Bedrock Gulch will likewise explain the remainder. The uniformity of occurrence of the ores is very striking and cannot but lead to the above conclusion.

The ores as stated above are confined to areas of igneous rocks and are found scattered through the exposures of syenite and diorite-monzonite-porphyry found in the gulch. All underground workings show the same conditions. The ore occurrence is peculiar and extremely interesting. The ore mineral is chalcopyrite and subordinately cupiferous pyrite. One very small occurrence of chalcocite has been found and there are a few veins of cuprite near the head of the gulch. In this area of cuprite veins the rock surfaces are quite generally stained with malachite, azurite and chrysocolla. The shipments of ore from Copper Hill were almost to the last ounce chalcopyrite and pyrite. These metallic minerals are related directly to fracturing and fissuring of the rocks. They are found filling openings, large or small, in the igneous rocks. At Copper Hill where the best exposures occur chalcopyrite and pyrite with sericite and kaolinite completely
must be the product of agencies which were operating long after both generations of rocks were formed. As far as the evidence in hand goes it is believed that the copper ores are of the "disseminated" type, that because of very intense fracturing of the crystalline igneous rocks of Bedrock Gulch ore solutions were able to penetrate the rock mass extensively and that the simple type of fissure filling has been the predominant type of ore formation. Replacement while accounting for a portion of the deposit has done so for a very small portion. The source of the ore bearing solutions and the ores is not known. The diorite stock of Bedrock Gulch furnishes a possible source for them but there is no proof and little suggestion that this has been the case. The diorite seems to be the most likely source and the solutions which deposited ores in Bedrock Gulch either came from this magma or from one whose presence has not been revealed.

One remarkable feature of the ores is the extreme shallowness of the oxidized zone and apparent absence of any secondary enrichment. Furthermore chalcopyrite, ordinarily easily oxidized is here found fresh and unaltered at the surface. At Copper Hill chalcopyrite is found at the grass roots and its condition does not change with the depth; in other parts of the gulch the same condition prevails. The divide at the head of the gulch contains considerable areas of weathered rocks. The weathering in such cases having gone almost to
fill fissures as much as four inches across. On all sides of these larger fissures small reticulated linear openings are also filled. Replacement of the wall rock has been of minor importance though there has been replacement to a slight extent. This is shown by minerals of the igneous rock being surrounded by the metallic minerals. Even in such cases it is difficult to determine whether the result has been accomplished by replacement of the igneous rock mineral or by filling of openings which extended completely around the mineral. Either condition might produce the same result. However isolated cases seem to be surely the result of replacement and the very isolation of such cases serves only to emphasize the minor rôle replacement has played in the formation of the ores. The relation of fracturing to the occurrence of the ore minerals is most strikingly shown under the microscope and seem almost conclusive evidence that the ore minerals were introduced after the rocks were fractured and that the fractures thus formed offered the channels through which solutions were able to bring metallic constituents to the positions they now occupy. In a report to the Copper Hill Company McCarthy suggested that the ores were part of the parent magma and were really segregation products of the syenite. This view seems untenable because not only do the ore minerals occupy definite rock openings but they occupy openings in two generations of rocks, namely, the syenite and diorite-monzonite-porphyry. They
completion as shown by extensive kaolinization of the feldspars.

At lower levels weathering, while quite advanced in some cases is not so complete in character. In this area of highly weathered rocks the only occurrences of oxidized copper mineral are found. These occurrences consist of veins of cuprite and rock surfaces stained with malachite, azurite and chrysocolla. The Copper Age amphitheater a bare rock surface located directly west of the Allard workings and the site of a small stream carries abundant copper stains over its entire length, some 1500 feet. The depth of the oxidation here cannot be determined for underground workings are almost entirely lacking. One prospect tunnel entering horizontally showed a fresh unaltered rock and chalcopyrite a few feet from the surface. The waters flowing down this amphitheater and down other channels in the gulch are known to carry copper but the amount is not known. It must be remembered that the areas of highly weathered rocks while quite large in extent are yet the smaller part of the mineralized portion of Bedrock Gulch and that the greater portion of the gulch is typically the unaltered chalcopyrite occurrence mentioned above. The question naturally arises as to the possibility of secondary enrichment. Was there once an oxidized zone of some extent over most of the gulch and was there a zone of secondary enrichment below this? If there was such an oxidized zone it has been removed over the greater part of the gulch. The
La Plata Mountains (l) were glaciated, Bedrock Creek occupies a hanging valley and a cirque exists at its head so that any oxidized zone extending into the lower portions of the gulch could have been removed most effectively by the erosive action of glaciers. Rapid erosion would tend to prevent the existence of a weathered zone of any extent. Erosion in Bedrock Gulch is rapid but it has been sufficiently tardy to allow the formation of highly weathered rocks which exist today at the higher levels of the gulch and which probably in a greater or less degree once existed everywhere. The combination of rapid erosion and glacial erosion in the lower levels apparently has very efficiently prevented the accumulation of any great mass of weathered materials in the lower portions of the gulch. The presence now or in the past of an enriched zone of secondary sulphides cannot be proved. Underground workings are too few in the weathered area to supply the necessary data. If such a zone did exist and it was a typical secondary zone characterized by chalcocite, it existed at a level above that occupied by the Copper Hill workings and was removed by glaciation for at Copper Hill chalcopyrite is the ore mineral and chalcocite is conspicuous by its complete absence. The possibility then arises of the chalcopyrite deposits being of secondary origin and that the deposits of chalcopyrite represent enriched zones. The occurrence of
secondary chalcopyrite has been noted by Boutwell (2) at the Highland Boy Mine at Bingham, Utah but the ores of this mine as described differ greatly from those of Bedrock Gulch. There chalcocite while of minor importance was present. Here there is an entire lack of this characteristically secondary mineral. Thin sections and polished specimens of the Highland Boy ore brought out plainly the relation of the secondary deposition to the primary. The ores under discussion show no such difference under the microscope. The entire uniformity of type of the mineral and the topographical relation of the ores seem to indicate a primary origin for them and such is believed to be the case.

Lead - Silver Ores

The lead-silver ores occur in three places in Bedrock Gulch only one occurrence of which is of considerable extent. In no other locality in the La Plata Mountains is this type of vein known to exist. In Bedrock Gulch these veins are best developed on the Black Rock claim of the Allard Mining Company just west of the Allard buildings and at a point one-half mile directly east of the divide at the head of Bedrock Creek. Float believed to be essentially in place is found on the ridge between Bedrock and Madden Creeks about one-half mile southeast of the Black Rock claim. A few small veins of this type are found in the divide at the head of the gulch
mineral belongs to the diopside-augite series and is dark green and extremely tough. Nowhere in the entire gulch is there to be encountered a tighter or tougher rock than found in these veins and they have this character because of the pyroxene present. This mineral occurs in interlocking groups of semi-fibrous crystals arranged so that while the mineral is in no sense actually fibrous its appearance is much like fine actinolite. The groups of crystals are slightly radiating and the extreme interlocking gives a horn like appearance to the mass. Upon alteration this pyroxene produces quartz, limonite, manganese oxides, calcium and probably magnesium carbonate. The most common weathering product is limonite and altered portions of these veins appear at first glance to be composed entirely of this mineral. Closer examination shows the limonite to be merely a thin coating upon the surface of the pyroxene. Under the microscope the pyroxene appears as a green slightly fibrous mineral all groups of crystals being oriented approximately the same way. Quartz occupies small spaces in the pyroxene and is present as crystalline quartz as far as observed. The galena which carries the lead and silver values is scattered generally throughout the green pyroxene occurring usually as disseminated grains but frequently also in masses which may be several inches across. The galena shows little change upon weathering and remains occupying
and northwest of the occurrence on Black Rock claim. Up to the present time only prospecting work has been done upon these veins and there has been no systematic effort made to develop their possibilities.

In the Black Rock claim mentioned above there are approximately one-hundred of these veins outcropping on a steep slope which forms the divide between two branches of Bedrock Creek. The country rock is the augite syenite in some cases and the diorite-monzonite porphyry, in others. The area over which they are exposed is approximately six hundred feet by fifteen hundred feet. The edges of the veins are to be seen outcropping on this slope and standing for the most part in a vertical position. A majority of the veins occupy northeast-southwest fissures but these cut off a few veins which occupy east-west fissures. The entire series of veins is blocked off into a rough rectangle by two of the major zones of fissuring mentioned in the discussion of structural geology. The occurrence mentioned above, on the divide between Madden Gulch and Bedrock Gulch lies in the continuation of one of the fault zones mentioned above as blocking of the series of veins. From this fact and the general structural features of the region this last occurrence is believed to be a faulted portion of the main block of veins on the Black Rock claim. The accompanying diagram illustrates these conditions. On the northward continuation of the most norther-
Fig. 7. Plat of Copper Hill workings.
ly fissure zone shown a few of the veins are found on the divide itself. Here they are on the north side of the fissure zone as they should be if conditions are as represented in the structural diagram. The three occurrences of these veins conforms exactly to the structural conditions as found in other parts of the region.

The veins as observed vary from stringers little more than one inch in shortest dimension to strong veins over three feet in shortest dimension. Approximately one half of the veins to be found exceed one foot across and can be traced nearly the entire length of the slope on which the whole series is exposed. Certain especially strong ones extend beyond this area and lose themselves beneath the soil many feet above the general area which contains the veins. All of the veins, large and small, are definite fillings of fissures and because of their darker color and greater resistance to weathering processes stand out conspicuously from the lighter colored country rock. Open space in the veins is almost entirely lacking and they are characteristically tight.

Minerallogically the veins consist of an intimate mixture of a dark green pyroxene, quartz and specks, grains and crystals of galena. Occasionally specks of pyrite are encountered but very rarely. The pyroxene mentioned is the mineral which determines the physical character of the veins for it is by far the most abundant mineral in the veins. This
the same space as before but surrounded by a mixture of limonite and quartz and partly altered pyroxene.

From a series of assays it has been found that these veins contain appreciable amounts of lead, silver and bismuth. The lead of course is in the galena and it is now believed that the silver and bismuth are also contained in an intimate association in this mineral. No distinct bismuth or silver mineral can be determined and the galena upon assaying yields results for both of these metals. Assays made from samples collected from parts of the vein in which there was apparently little galena showed low values in silver and bismuth while those selected from portions of the veins in which galena was conspicuous carry larger amounts of the silver and bismuth. The average silver content of the veins estimated from the assays made so far is believed to be between fifteen and twenty-five ounces per ton while the average for bismuth is between fifteen and forty-five pounds per ton. No figures are available for the lead for all assays were made for silver and bismuth only. As a mining proposition these deposits exhibit attractive possibilities because of the number of veins and the large tonnage of material present.

Since the dominant mineral of the veins is pyroxene, since the veins show very little open space and because they are found in intrusive bodies of igneous rocks and are near other bodies of igneous rocks the veins are thought to be due
to igneous action working at intermediate or great depths. The principal mineral the pyroxene is characteristic of igneous conditions and the other minerals while not so common to such conditions are still within the possibilities. For all of these reasons these veins are regarded as having been formed at intermediate or great depths. If this conclusion is true it is obvious that continuation in depth of these veins is very possibly the case. There is no reason to believe that the veins will become smaller in depth or that the values will become less. Likewise there is no reason to believe that they will become larger or their values greater.

In summation there is an occurrence of definite veins in Bedrock Gulch. These occupy fissures conforming to the observed fracture system of the region and carry values in lead, silver and bismuth. They are believed to be of magmatic origin.

Commercial Considerations

No discussion of the geology and ore deposits of Bedrock Gulch would be complete without a consideration of the commercial possibilities of the ores. At the time the field work for this report was being done there was no attempt at mining the deposits being made. Before the late war as has been mentioned the Copper Hill group of claims was operated profitably on a small scale for a period of about three years. Lately all of the claims in the gulch have been consolidated
into the property of the Colorado Consolidated Copper Mines and it is understood that an attempt will be made to develop and exploit the ore deposits of the gulch.

An analysis of the situation that existed at Copper Hill shows that shipments of crude ore contained from 3-8% copper with a small value also in silver. The only attempt at milling was a rough hand sorting to bring the lower grade portions up to three or four percent. This manner of operation cannot be carried on today. Smelter charges, mining costs and transportation at present day prices would effectually prohibit any such method of treatment. The main chance here of course lies in concentrating the ore by milling. The ore is certainly of a type to lend itself to concentration for all of the heavier constituents are the ore minerals themselves. There is no excess of valueless sulphide to lower the grade of the concentrate. The amount of ore blocked out at the present time at Copper Hill is probably ample to warrant the erection of a small test mill provided there is reasonable hope of the discovery and development of similar bodies of ore in the gulch. Such a mill could be so located as to be able to serve for all of the first development work of the entire gulch. The erection of this mill should be undertaken only after complete metallurgical tests of the ores have been made and after the cost situation in relation to the available ore at Copper Hill has been completely determined. If this seems
8. Illustration of Copper Hill Ore.
to give a fair margin and if favorable rates can be secured from the smelter the erection of a mill for the treatment of the copper ores should receive first consideration in the development policy to be pursued on the deposits of the gulch as a whole.

What are the chances for other copper bodies in the remainder of the gulch and how should they be developed? The whole consideration here is that of determining the percentage of copper and other valuable constituents contained in the known showings of chalcopyrite and other copper minerals. It is believed that this report has demonstrated that geologic conditions are favorable for continuity in depth and size of the ore bodies. Extensive sampling alone then can show if the wide area over which copper showings are known is worthy of further investigation. Conditions analogous to those at Copper Hill would seem to indicate that there is a good chance for sufficiently high values in these known areas of mineralized rock. A written communication from Mr. R.D. McCausland engineer of the company interested in the copper deposits states that since the field work was done, sampling near the head of the gulch, indicates as far as it had progressed at the time of the communication the presence of at least one block of ground of large extent with a tenor of about four per cent copper. More detailed work on the
northwest-southeast faults may show the presence of blocks of ore of which there is no surface indication known at present. Copper Hill is an isolated block and while one extension is believed to be known the other may perhaps also be discovered with the right sort of investigation.

The lead silver-veins which have been described previously should be attacked along similar lines as the copper deposits. The presence of such a large number of veins which as far as known always carry a fairly constant silver content will certainly justify their development. Again of course their metallurgical nature should as definitely determined as possible and all factors involved in the mining and marketing of the product investigated before any great development is attempted. More complete sampling than has been done previously is to be recommended. If these veins are found to be of sufficient value to operate under present conditions the question of a mill would also probably arise. Any mill to treat these ores should be designed if possible in such a way that it could also be used to treat the copper ores of the gulch for at least the first stages of development work. The relatively high assay value of these veins, their large numbers, their constant character and geological nature make them only slightly less attractive a mining proposition than the copper ores.

The feature of all the deposits of Bedrock Gulch that should be emphasized is that here are very large deposits very favorably situated. The area covered by promising copper
showings and the area covered by the veins taken together is very large. The values to be sure are not remarkably high but the day of large high grade ore deposits in North America has passed. Such deposits belonged to the pioneers. Today modern methods of mining and milling permit the exploitation of much lower grade deposits than formerly if the size of the deposit insures an operation over a long period of time. Any large ore deposit even though it is of low grade should be completely investigated. The copper and lead-silver deposits of Bedrock Gulch are certainly of this character. Their possibilities are believed to be great and their complete investigation is strongly recommended though no man can tell definitely what can be expected until some development work has been completed. If the blocked out bodies of ore at Copper Hill are found to be large enough to justify the erection of a mill it should be used fully as much for the development of the possibilities of the rest of the gulch as for the treatment of the actual Copper Hill ores. Every effort should be made under these circumstances to discover and block out bodies of copper ore until the resources of the entire gulch are known as completely as possible. Knowing this the advisability of further work or further plant installation will be a simple matter. It is worthy of note even in this report that conditions in Bedrock Gulch are ideal for the development of a large ore body for readily accessible are to be found coal, lumber, water and railway transportation. To summarize
the deposits of this gulch since they are of large extent merit an effort toward their development and commercialization. Truly "the waste of yesterday is the ore of today," and the several low grade copper deposits of the west which are so important today were once in exactly the same category as those of Bedrock Gulch.

(1) Atwood and Mather, Jour. Geol., Vol. 20. p. 386.